Clinical Update: iCMR EP

Saman Nazarian, MD, PhD

Associate Professor, Cardiac Electrophysiology

University of Pennsylvania Perelman School of Medicine

PennCVI
Cardiovascular Institute

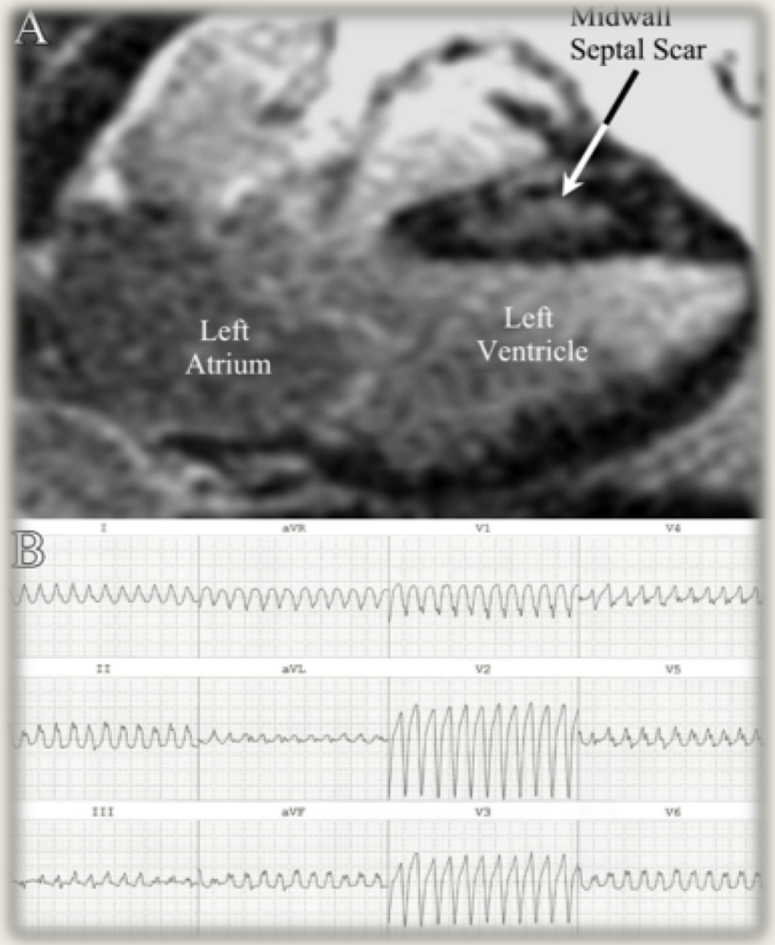
Thursday 5:55-6:05 PM

Disclosures

- **Consultant**
  - *Biosense Webster Inc*
  - *Siemens Inc*
  - *ImriCor Inc*
  - *CardioSolv Inc*
- PI for national study
  - *St Jude Medical (now Abbott)*
- **PI for Research grants**
  - *NIH NHLBI*
    - R01HL116280
    - R01HL142893
  - *Siemens Inc*
  - *Imricor Inc*
  - *Biosense Webster Inc*

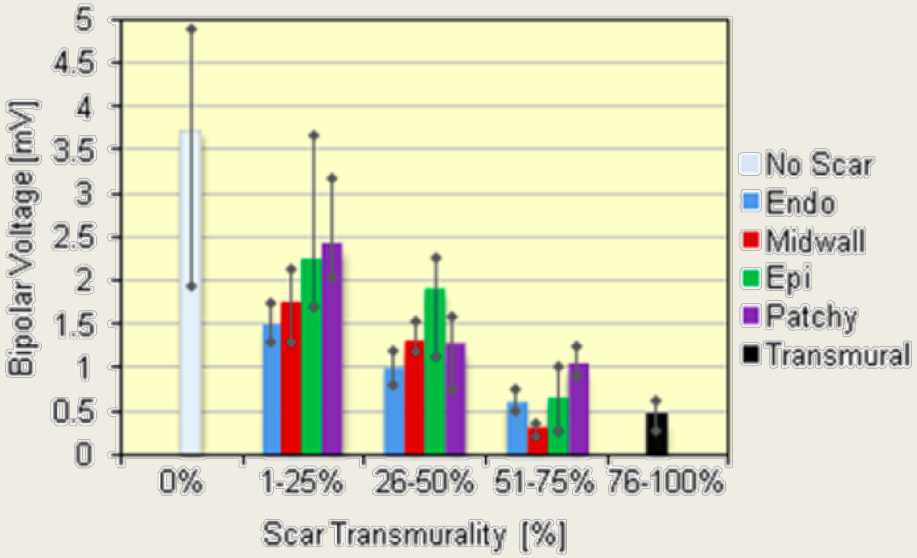
The Reentry Substrate for Non-ischemic Cardiomyopathy

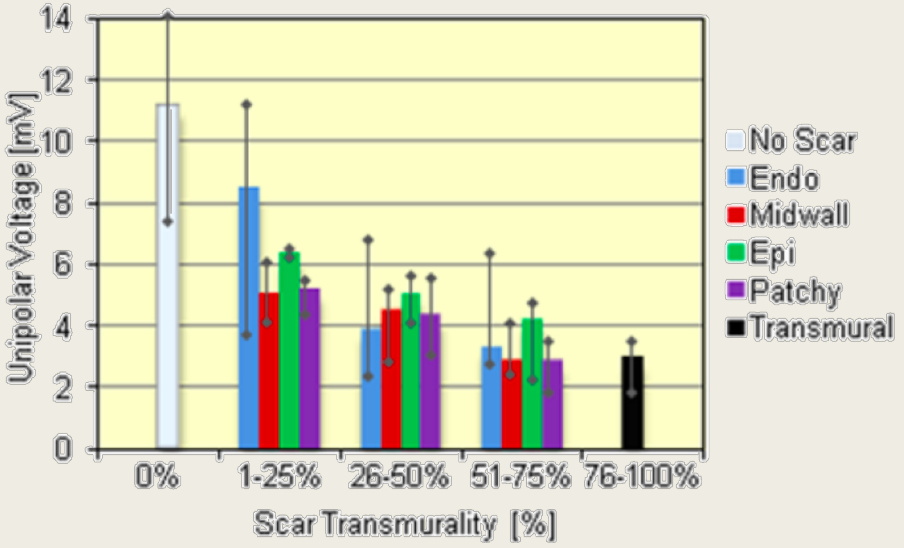
- We performed CMR imaging in 26 patients with NICM prior to EP study
- Midwall scar with > 25% scar transmurality was associated with inducible VT
  - *OR 9.1, P=0.02 (multivariable analysis)*
- Morphology of VT was consistent with an exit site near the visualized scar

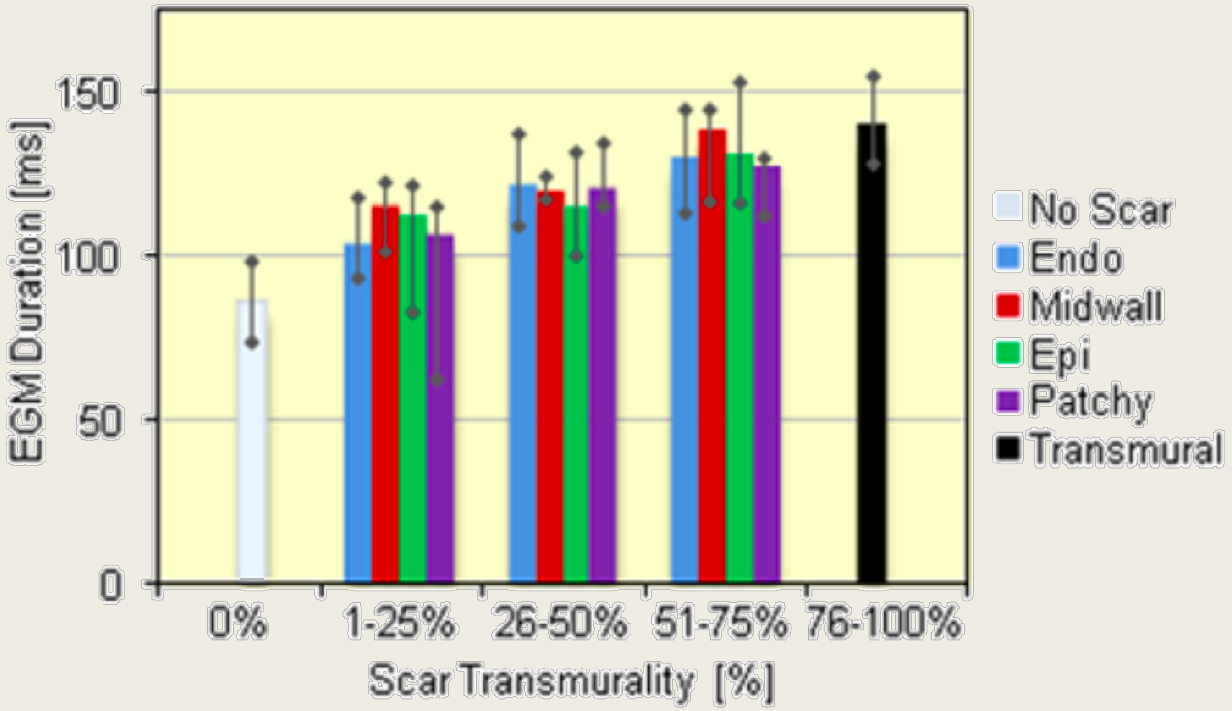


Nazarian et al. Circulation. 2005 Nov 1;112(18):2821-5

Association of LGE and EGM Characteristics in NICM

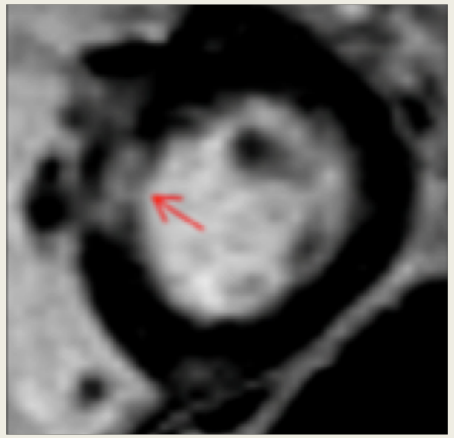


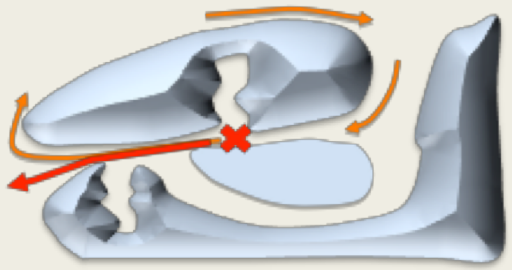


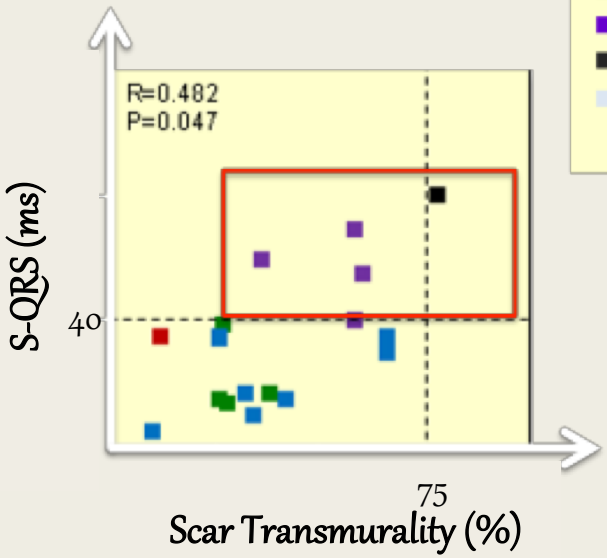


Sasaki, Nazarian et al. Circ Arrhythm Electrophysiol. 2013 Dec;6(6):1139-47

VT Circuit Sites and Scar Transmurality in NICM



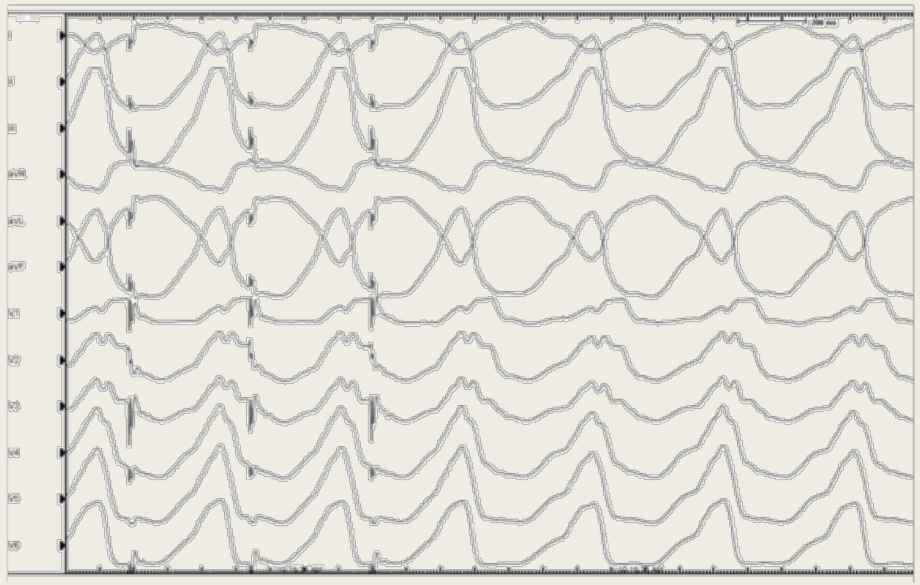


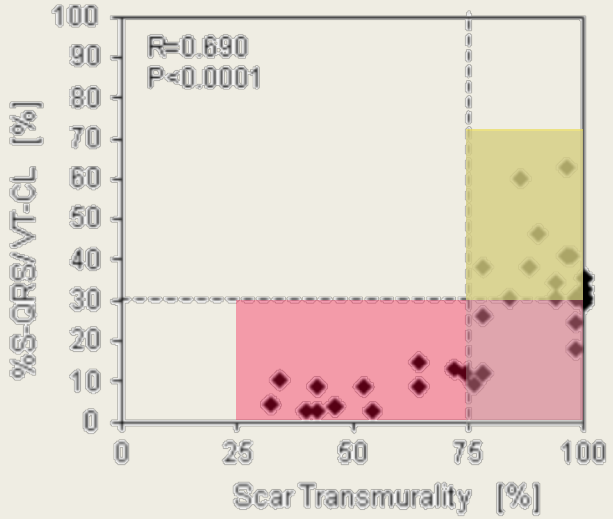


Slow conduction regions defined by >40 msec of S-QRS delay, were confined to regions with >75% scar transmurality or patchy scar.

Sasaki, Nazarian et al. Circ Arrhythm Electrophysiol. 2013 Dec;6(6):1139-47

Anatomy of Ischemic VT Circuit Sites





%S-QRS/VT-CL

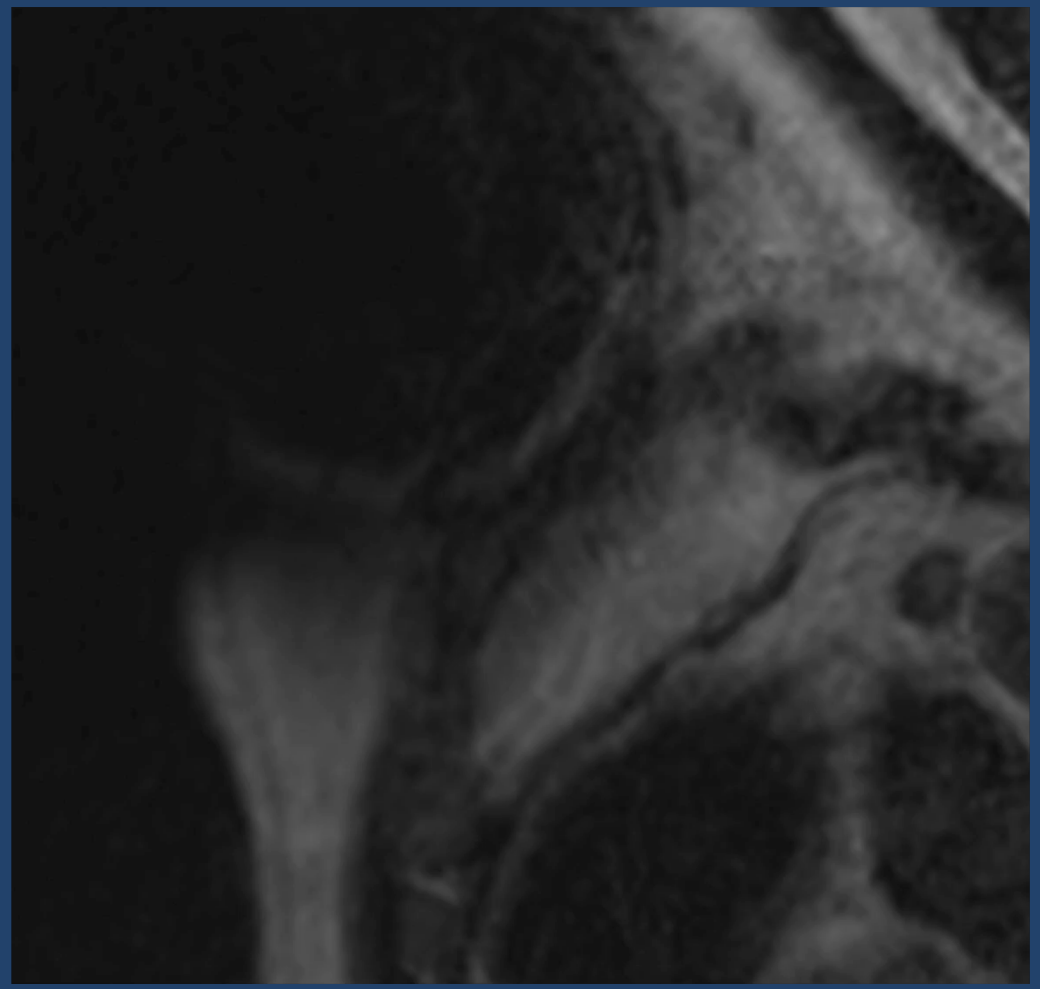
VT exit sites <30%

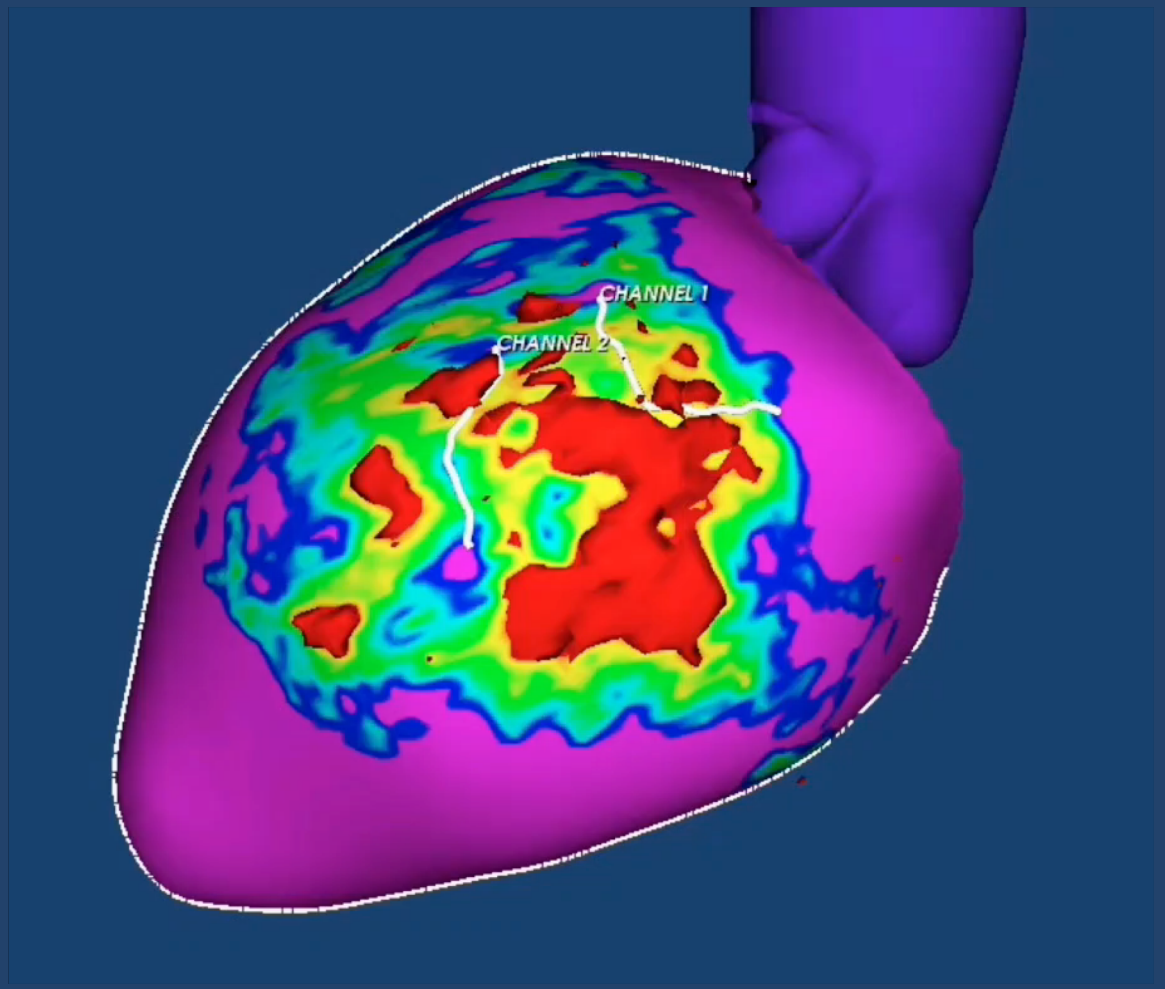
Central Pathway 30-70%

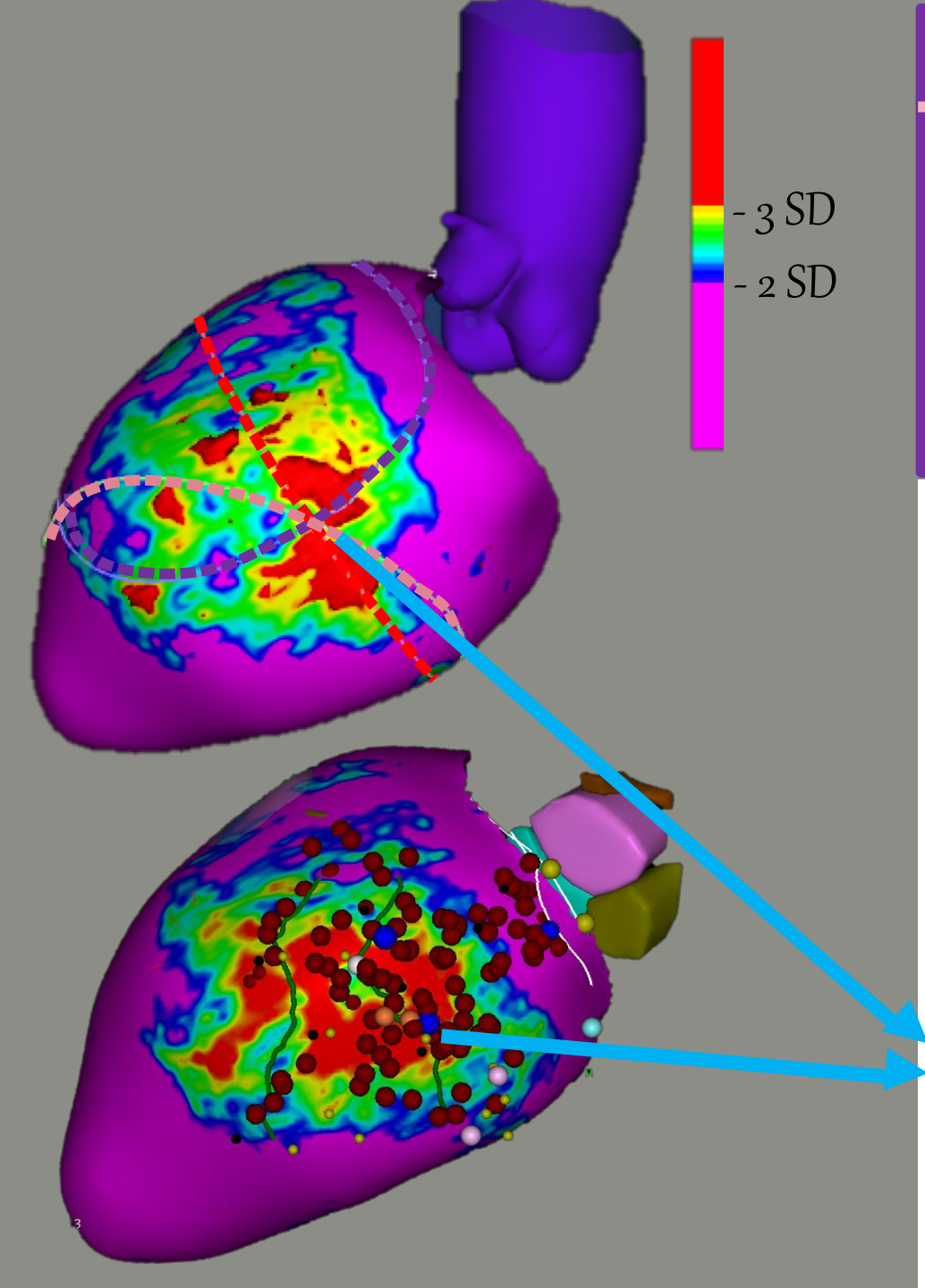
Targeting sites with >75% scar transmurality with ablation would eliminate central pathway VT sites with 100% sensitivity and 65% specificity

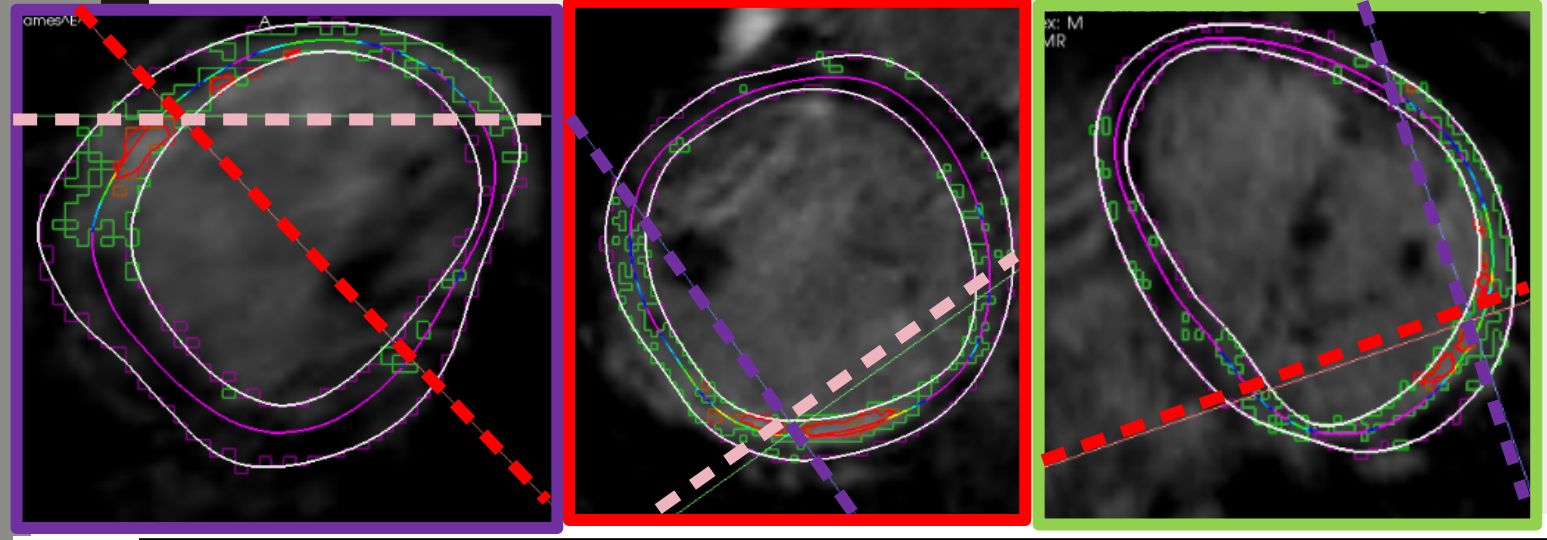
Sasaki, Nazarian et al. Circulation A&E 2012;5:1081-1090

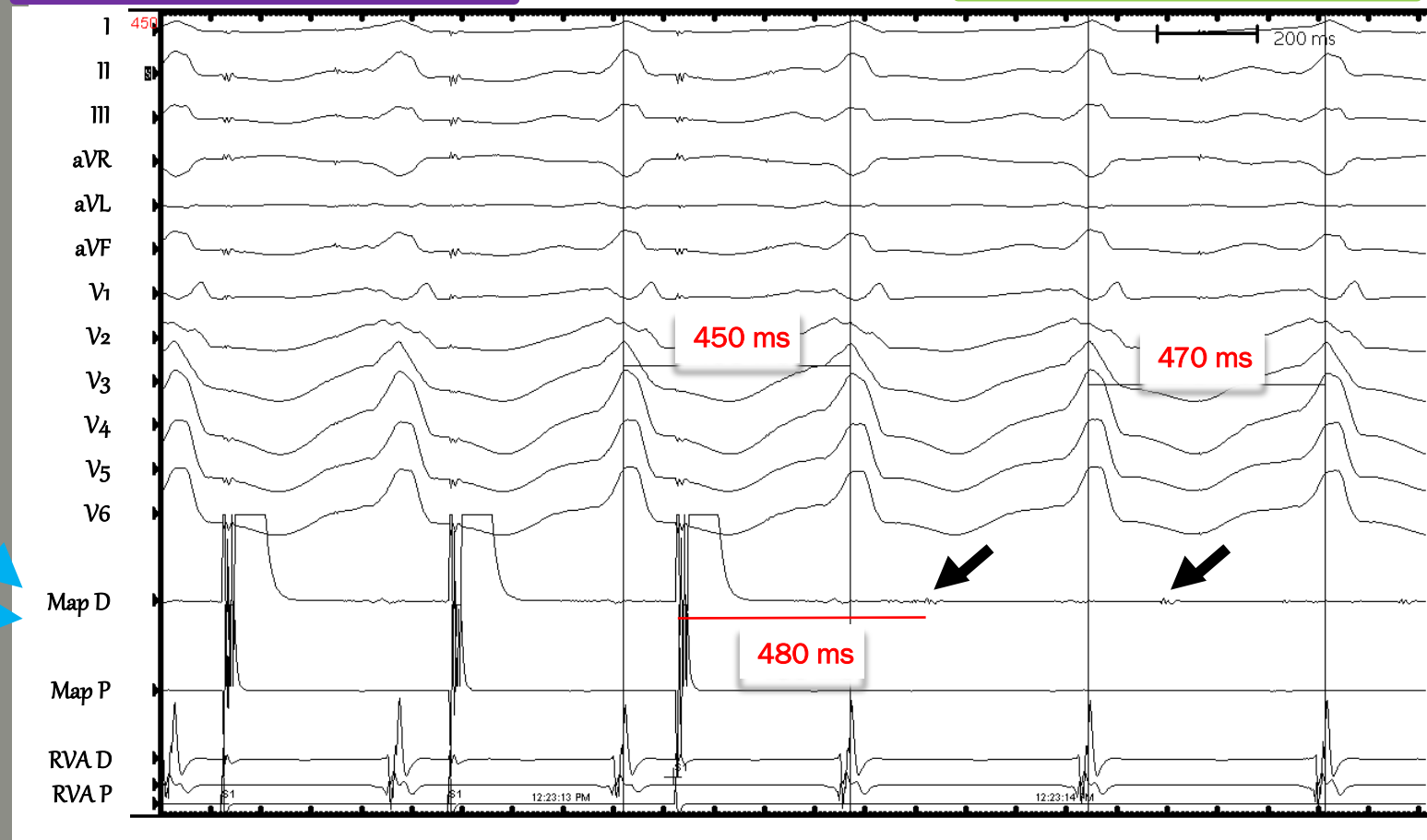
Channel Visualization

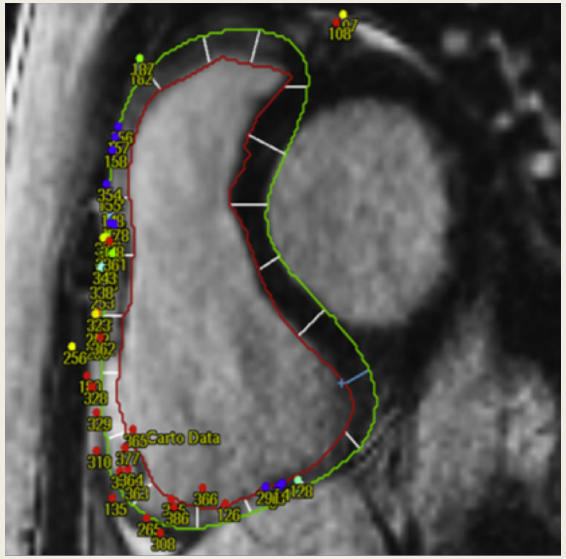




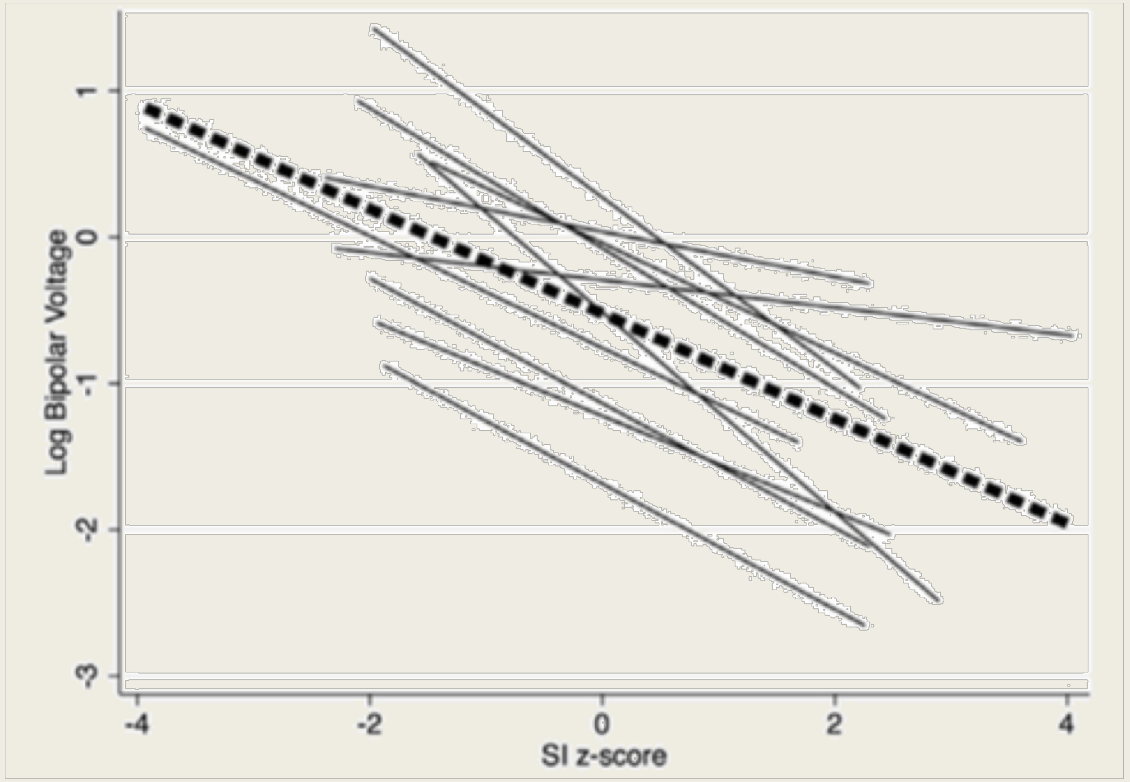

- 3 SD
- 2 SD



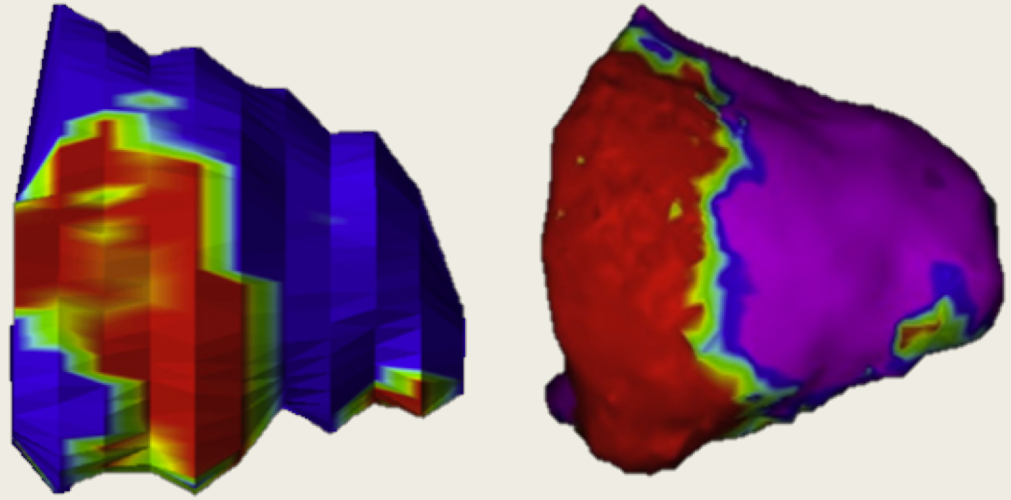

I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
Map D
Map P
RVA D
RVA P
200 ms
450 ms
470 ms
480 ms



$$z = \frac{x - \mu}{\sigma}$$

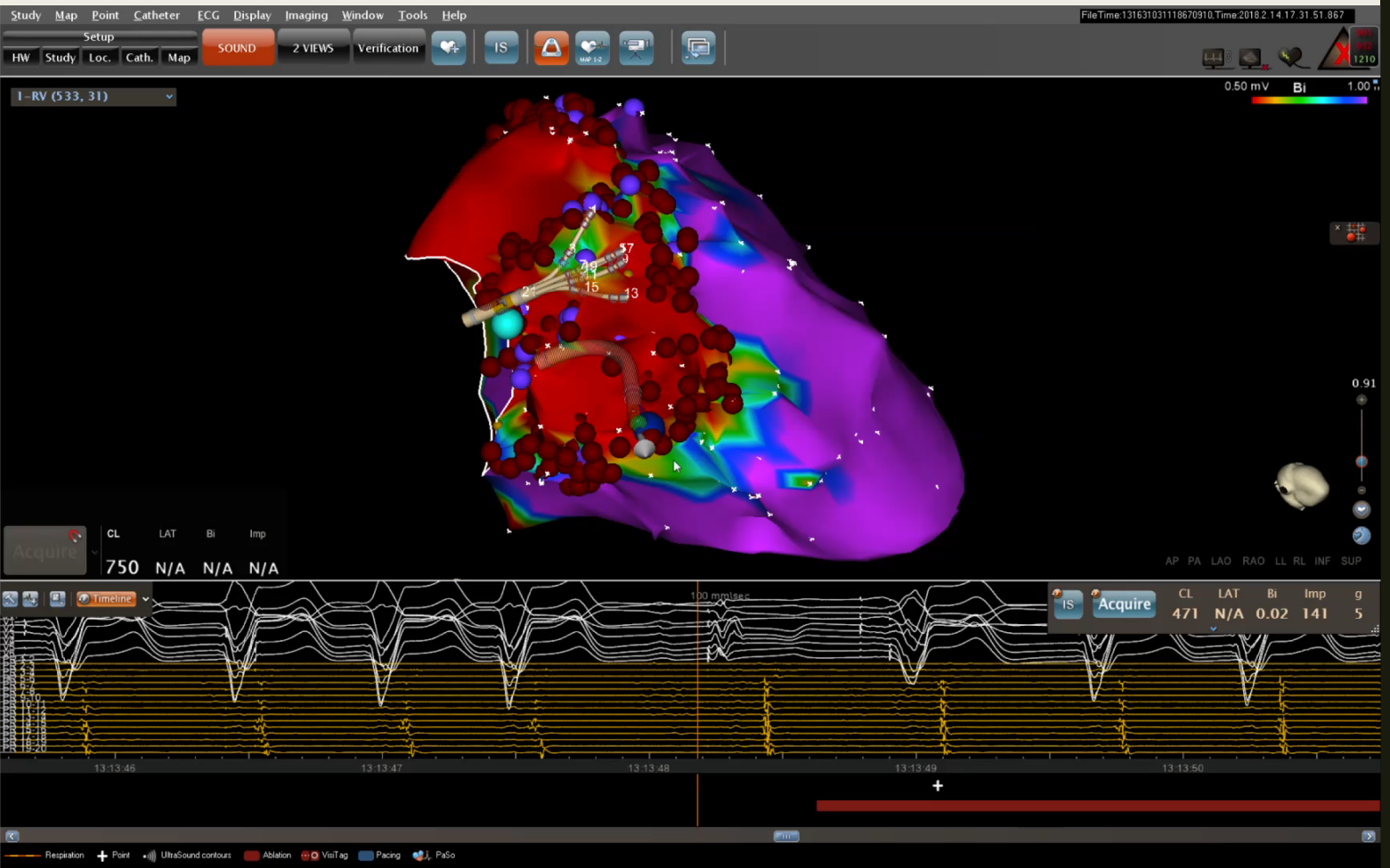


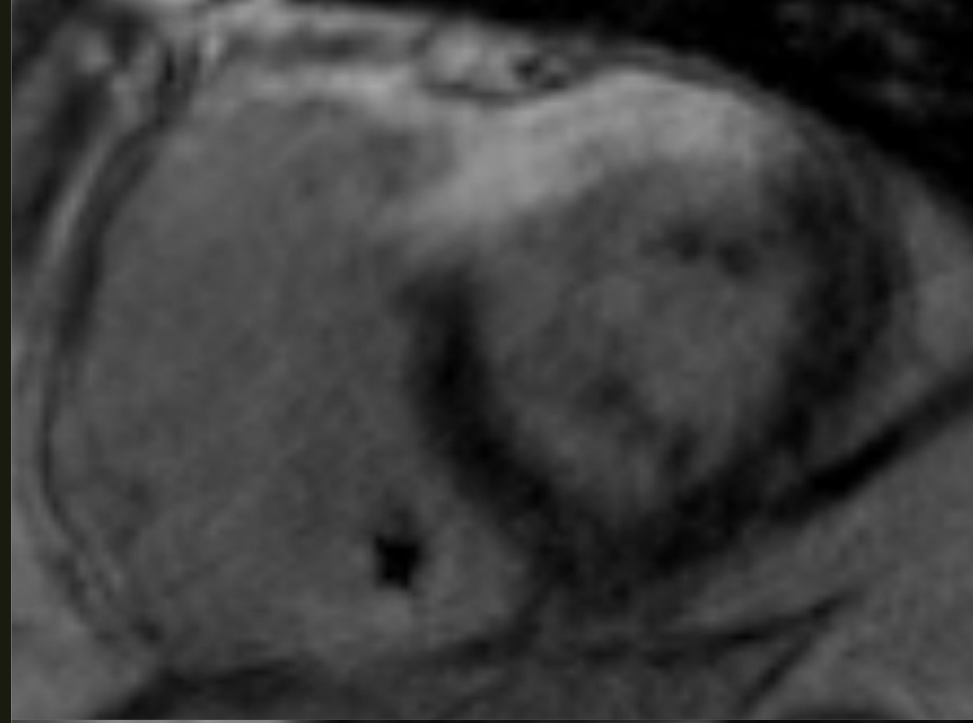
- Patient-clustered (n=10), GEE models that included 3205 epicardial sites, showed that EGM amplitude is associated with regional SI z-scores
  - *Bipolar : -1.43 mV/z-score, P <0.001*
  - *Unipolar : -1.22 mV/z-score, P <0.001*
- SI z-score thresholds corresponding to bipolar voltage measures were determined:
  - ***<0.5 mV: z-score >0.05***
  - ***>1.0 mV: z-score <-0.16***



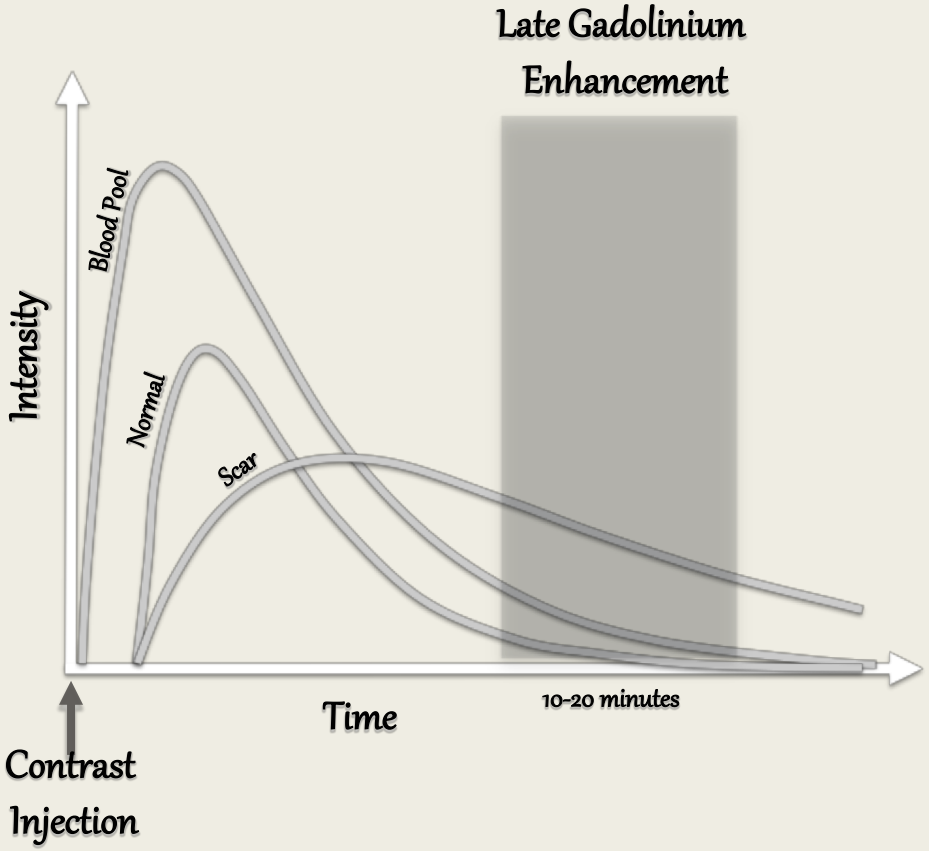
Xie, Nazarian et al. Heart Rhythm. 2018 Mar 2. In Press.

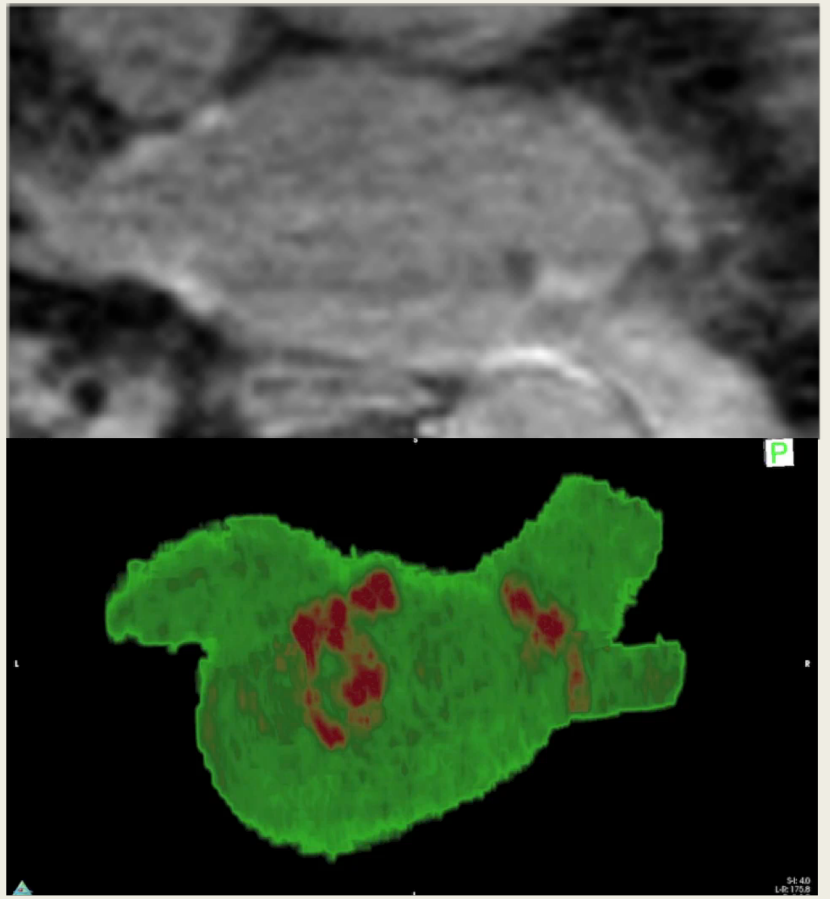
Applicability to clinical ARVC VT ablation? Endocardial ablation to eliminate the epicardial substrate



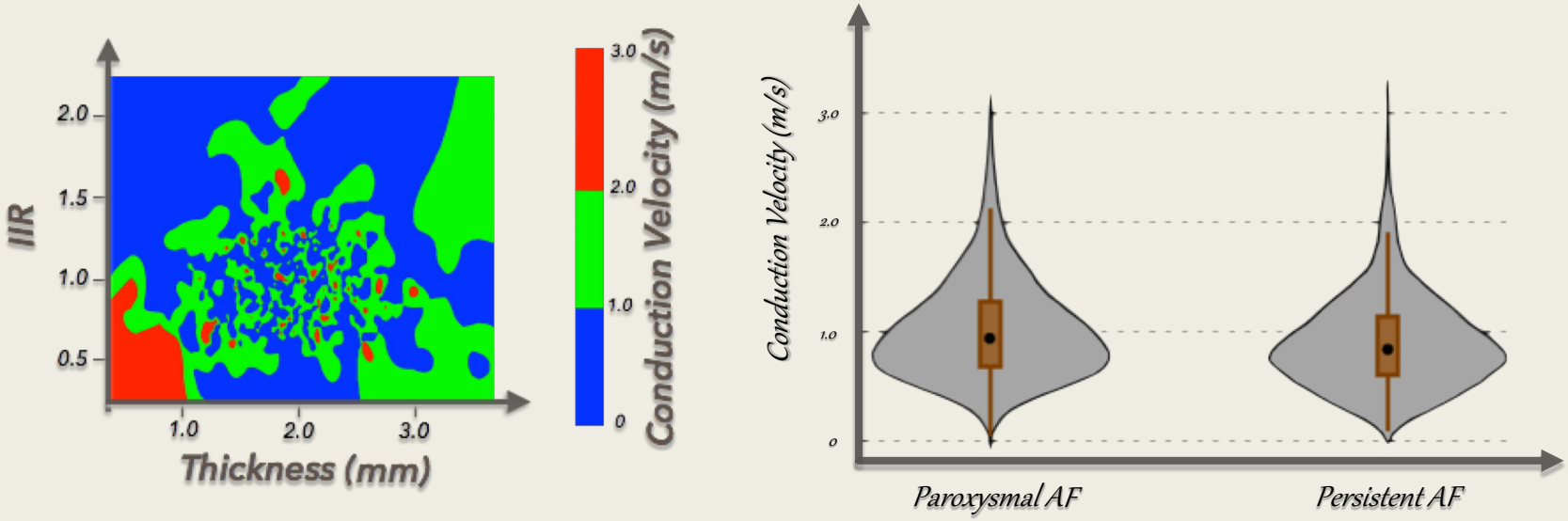


Left Atrial LGE





Conduction Velocity and LGE



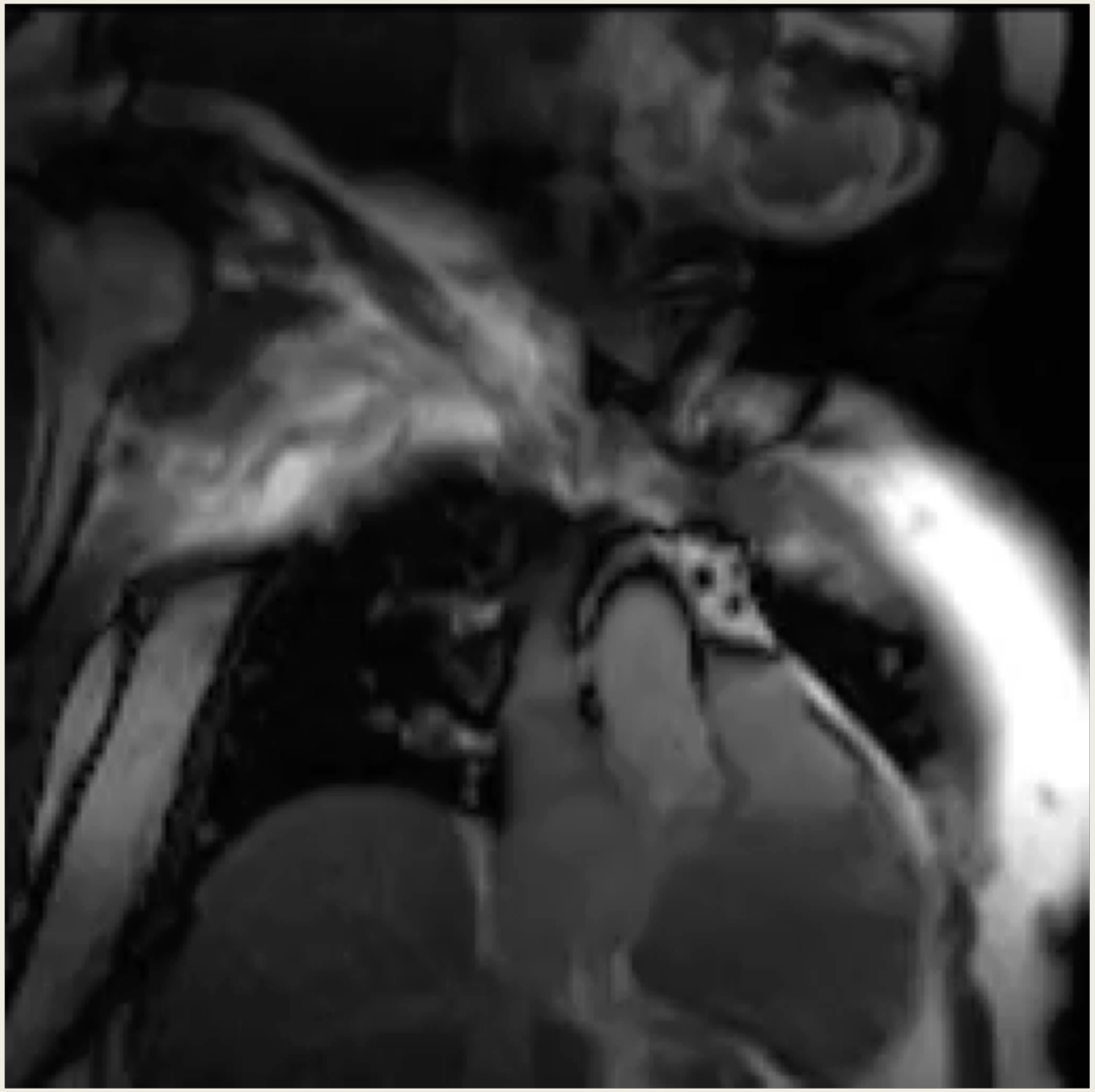
* Data from 22 patients with activation mapping during sinus rhythm

- Increased LGE extent and intensity is associated with lower conduction velocity
- Conduction velocity is lower in patients with persistent AF
- Atrial scar may result in AF sustenance by promoting slow and non-uniform conduction

Fukumoto, Nazarian et al. Circ Arrhythm Electrophysiol. 2016 Mar;9(3):e002897.

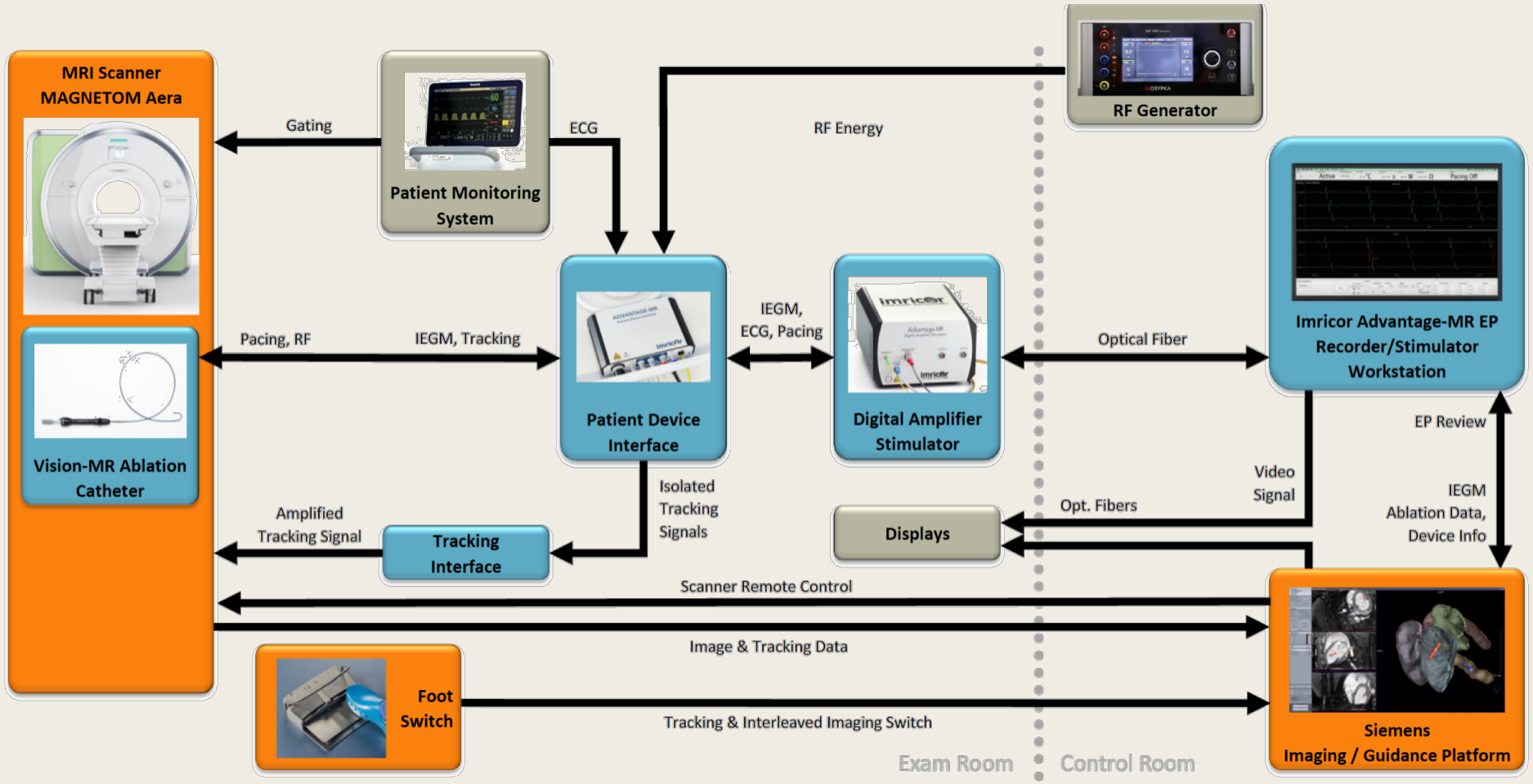
Real-Time MRI for Catheter Guidance in EP Studies

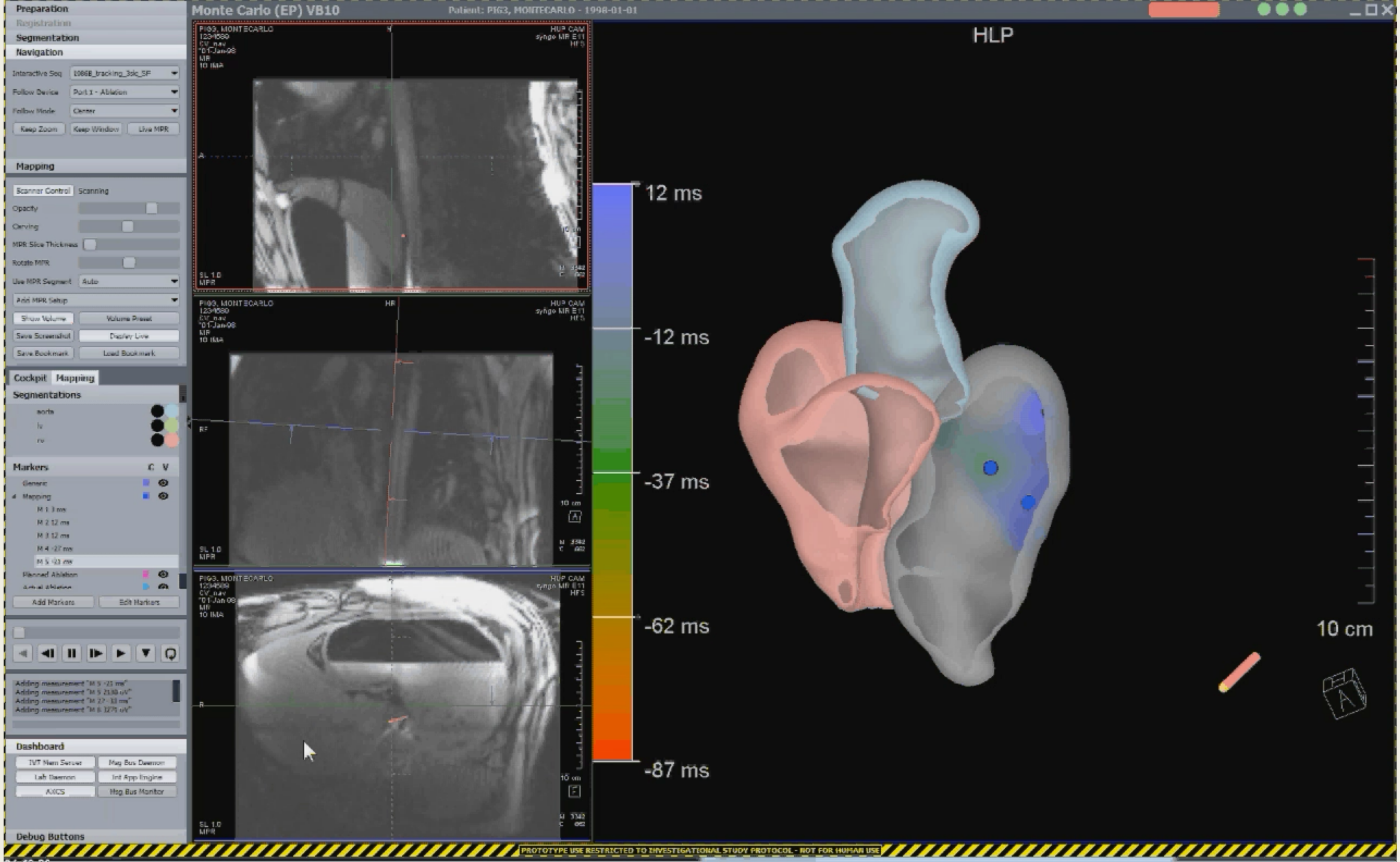
- An MRI-compatible EP system was developed.
- Catheters were targeted to the HRA, His, and RV in 10 mongrel dogs (23 to 32 kg) via a 1.5-T MRI system using rapidly acquired fast gradient-echo images (≈5 frames per second).
- Comprehensive EP studies with recording of intracardiac electrograms and atrial and ventricular pacing were performed.
- Limited real-time MRI-guided catheter mapping studies were performed in 2 patients.

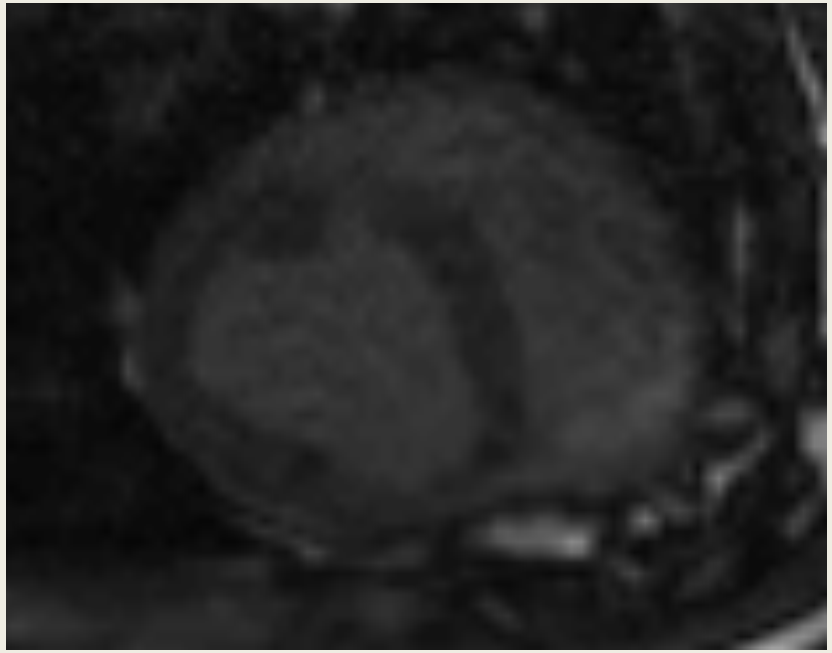


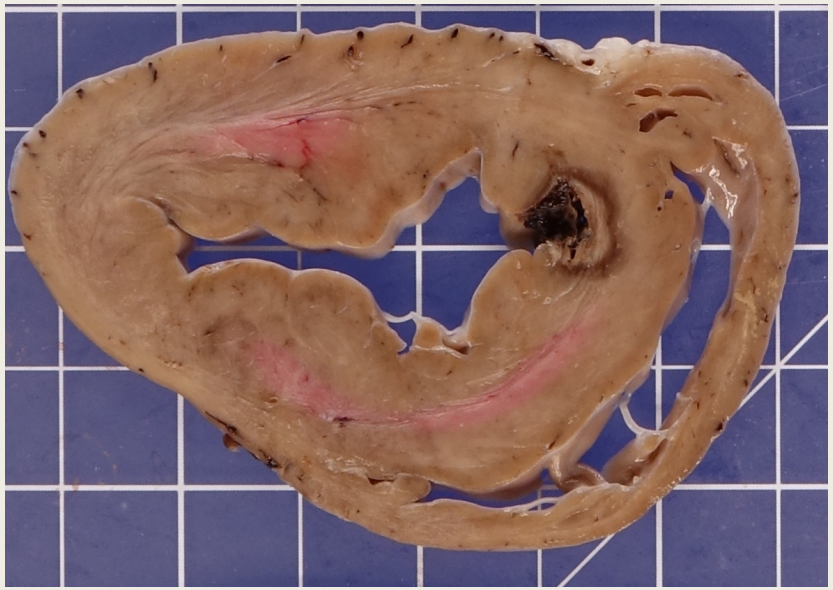
Nazarian et al. Circulation. 2008 Jul 15; 118(3): 223–229

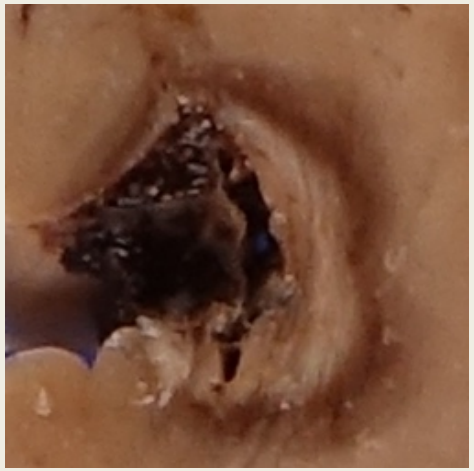
Real-Time MRI for Ablation Procedures: The ImriCor Siemens System




Monte Carlo (EP) VB10
Patient: PIG3, MONTECARLO - 1998-01-01
Preparation
Registration
Segmentation
Navigation
Mapping
Cockpit
Mapping
Segmentations
Markers
Add Markers
Edit Markers
Dashboard
Debug Buttons
HLP
12 ms
-12 ms
-37 ms
-62 ms
-87 ms
10 cm
PROTOTYPE USE RESTRICTED TO INVESTIGATIONAL STUDY PROTOCOL - NOT FOR HUMAN USE







MAGNASAFE and our registry results, led CMS to expand MRI coverage in the setting of devices

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Safety of Magnetic Resonance Imaging in Patients with Cardiac Devices

Saman Nazarian, M.D., Ph.D., Rozann Hansford, R.N., M.P.H., Amir A. Rahsepar, M.D., Valeria Weltin, M.S., Diana McVeigh, B.S., Esra Gucuk Ipek, M.D., Alan Kwan, M.D., Ronald D. Berger, M.D., Ph.D., Hugh Calkins, M.D., Albert C. Lardo, Ph.D., Michael A. Kraut, M.D., Ph.D., Ihab R. Kamel, M.D., Ph.D., Stefan L. Zimmerman, M.D., and Henry R. Halperin, M.D.

- 1509 patients, 58% with a pacemaker and 42% with an ICD that underwent 2103 thoracic and non-thoracic MRI examinations 1.5 Tesla.
- No long-term clinically significant adverse events were reported.

- In 9 MRI examinations (0.4%; 95% CI, 0.2 to 0.7), power-on-reset occured. The reset was transient in 8 but permanent in 1 at battery EOL prior to scan, which required replacement.
- The observed changes in lead parameters were not clinically significant and did not require device revision or reprogramming.

Time of Assessment and Variable	No. of Patients†	Baseline Setting	Decrease from Baseline				≤20% Change from Baseline	Increase from Baseline			
			>50%	41–50%	31–40%	>20–30%		>20–30%	31–40%	41–50%	>50%
		median (IQR)	*number of patients (percent)*								
Immediately after MRI											
P-wave amplitude	1347	3.0 (2.0–4.6) mV	13 (1)	26 (2)	35 (3)	97 (7)	1049 (78)	32 (2)	53 (4)	28 (2)	14 (1)
RV R-wave amplitude	1799	11.2 (8.0–14) mV	5 (<1)	4 (<1)	15 (1)	117 (6)	1583 (88)	20 (1)	35 (2)	12 (1)	8 (<1)
LV R-wave amplitude	72	11.4 (7.0–19.7) mV	0	0	2 (3)	5 (7)	61 (85)	2 (3)	2 (3)	0	0
Atrial lead impedance	1559	473 (413–540) ohms	0	0	1 (<1)	2 (<1)	1553 (100)	3 (<1)	0	0	0
RV lead impedance	2021	532 (448–640) ohms	0	0	1 (<1)	4 (<1)	2014 (100)	2 (<1)	0	0	0
LV lead impedance	202	629 (512–769) ohms	0	0	0	1 (<1)	201 (100)	0	0	0	0
Atrial capture threshold	1338	0.8 (0.5–1.0) V	2 (<1)	28 (2)	37 (3)	32 (2)	1143 (85)	17 (1)	36 (3)	34 (2)	9 (<1)
RV capture threshold	1969	0.8 (0.7–1.0) V	3 (<1)	32 (2)	45 (2)	54 (3)	1669 (85)	39 (2)	65 (3)	47 (2)	15 (<1)
LV capture threshold	200	1 (0.8–1.5) V	1 (<1)	3 (2)	4 (2)	7 (4)	164 (82)	10 (5)	7 (4)	4 (2)	0
Battery voltage	1578	2.8 (2.8–3.0) V	0	0	0	0	1577 (100)	0	0	1 (<1)	0
At long-term follow-up after MRI‡											
P-wave amplitude	826	3.1 (2.0–4.7) mV	29 (4)	42 (5)	39 (5)	91 (11)	498 (60)	33 (4)	37 (4)	25 (3)	32 (4)
RV R-wave amplitude	1072	11.2 (8.0–13.8) mV	8 (1)	21 (2)	54 (5)	101 (9)	732 (68)	53 (5)	46 (4)	24 (2)	33 (3)
LV R-wave amplitude	26	19.7 (10.0–25.0) mV	0	0	1 (4)	0	20 (77)	3 (12)	1 (4)	1 (4)	0
Atrial lead impedance	1021	475 (416–548) ohms	0	1 (<1)	6 (1)	22 (2)	975 (96)	11 (1)	3 (<1)	1 (<1)	2 (<1)
RV lead impedance	1286	535 (447–644) ohms	1 (<1)	3 (<1)	9 (1)	26 (2)	1214 (94)	25 (2)	3 (<1)	1 (<1)	4 (<1)
LV lead impedance	106	675 (538–830) ohms	0	1 (1)	0	2 (2)	100 (94)	3 (3)	0	0	0
Atrial capture threshold	725	0.8 (0.5–1.0) V	4 (1)	28 (4)	47 (6)	37 (5)	469 (65)	19 (3)	43 (6)	48 (7)	30 (4)
RV capture threshold	1105	0.8 (0.7–1.0) V	10 (1)	41 (4)	66 (6)	71 (6)	693 (63)	48 (4)	63 (6)	65 (6)	48 (4)
LV capture threshold	105	1 (0.8–1.4) V	0	5 (5)	5 (5)	6 (6)	64 (61)	4 (4)	10 (10)	8 (8)	3 (3)
Battery voltage	930	2.8 (2.8–3.0) V	0	0	0	4 (<1)	925 (100)	1 (<1)	0	0	0

Nazarian et al. N Engl J Med. 2017 Dec 28;377(26): 2555-2564

Conclusions

- The location of critical components of ventricular scar for myocardial reentry can be estimated by MRI
  - *In or directly adjacent to regions with dense scar*
- Real-time MRI guidance of EP procedures is moving forward with wider enthusiasm by clinicians and industry
- Restrictions for MRI in the setting of implanted devices have been overcome

Thank you

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